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(54) **EQUIPMENT FOR IMAGING BY SPECT**

BILDERZEUGUNGSSYSTEM FÜR SPECT

MATÉRIEL POUR L'IMAGERIE PAR SPECT

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Description

[0001] The invention relates to a collimator for use in the method of imaging a target organ in a patient by SPECT, to a combination of a gamma detector and a collimator, and to a gamma camera, provided with said combination.
The invention also relates to an equipment for performing the method of imaging a target organ in a patient by SPECT, by using the so-called LOrA technique, which equipment comprises at least one detector-combined collimator.

[0002] The Single Photon Emission Computed Tomography (SPECT) is routinely used in clinical studies. SPECT is performed by using a gamma camera, comprising a collimator fixed on a gamma detector, which gamma camera follows a revolution orbit around the patient's body. The gamma rays, emitted by a radioactive tracer, accumulated in certain tissues or organs of the patient's body, are sorted by the collimator and recorded by the gamma detector under various angles around the body, the collimator always pointing to (facing) the rotation axis of the camera. From the acquired planar images the distribution of the activity inside the patient's body can be computed using certain reconstruction algorithms. Generally the so-called Expectation-Maximization of the Maximum-Likelihood (EM-ML) algorithm is used, as described by Shepp et al. (IEEE Trans. Med. Imaging 1982; 2:113-122) and by Lange et al. (J. Comput. Assist. Tomogr. 1984; 8:306-316). This iterative algorithm minimizes the effect of noise in SPECT images.

[0003] The collimators nowadays in use are manufactured from a lead sheat perforated with a plurality of usually parallel holes. The collimator is the most problematic element of the SPECT device, with regard to its poor sensitivity (less than 0.01% of the gamma radiation passes the collimator and reaches the detector) and its poor spatial resolution, becoming increasingly worse with increasing distance between activity source (i.e. the organ or tissue wherein the radioactivity has been accumulated) and collimator. Improvement of one of these properties, e.g. by modifying the hole length or diameter of the collimator, is always to the detriment of the other one. Furthermore, the SPECT technique is inadequate in producing reliable images because of the fact that small fluctuations in the acquired data can involve significant variations in the reconstructed images. This is due to the geometry of the acquired data. The limited time available for obtaining the necessary information (because of the restricted fixation time of the patient and the decay time of the radioactive tracer) and the limited injected radioactivity dose (limited for health care reasons) lead to acquired images containing statistical noise. Indeed the measurement of a radioactive process follows the Poisson law, giving a signal to noise ratio proportional to the square root of the count rate. As a result, the reconstructed images are frequently corrupted by significant false positive information, so-called noise artefacts. Consequently, it is a major goal in SPECT imaging to increase the SPECT sensitivity without reduction of the spatial resolution in order to improve the acquired signal to noise ratio.

[0004] Therefore it is the objective of the present invention to provide an improved equipment for performing the method of imaging a target organ by SPECT.
This objective can be achieved, according to the present invention, by using in said equipment a so-called rake collimator, which comprises, in addition to a plurality of collimator septa in a mutually parallel arrangement, at least one raised wall, considerably larger than the septa and transversally positioned thereto.
Surprisingly it has been found, that by using such a rake collimator in combination with a gamma detector, wherein said at least one raised wall of the collimator extends outwards in the longitudinal direction of the detector, a considerable improvement of the sensitivity-resolution couple can be obtained.

[0005] Preferably the collimator is outwards provided with one or two raised walls.
In case the collimator is provided with a single raised wall, this wall preferably extends perpendicularly from a common central line of the septa.
In case the collimator is provided with two raised walls, these walls are preferably slanted inwards from the ends of the septa to form, in cross section, the sides of a trapezium with a topline-length of approx. 3 to approx. 12 mm.

[0006] To improve their results, gamma cameras for SPECT imaging are often adapted to the special organs to be studied (organ-dedicated), for example, head-dedicated equipment for specific study of the head (by using an annular camera), etc. The heigth of the septa is normally 3 or 4 cm. If in the method of the invention head-dedicated cameras are preferred, such cameras have only to be equipped with rake collimators, having said at least one raised wall extending beyond said septa over a distance of approx. 8 or 9 cm, measured perpendicularly with respect to the outer surface of the detector. Rake collimators, having said at least one raised wall extending beyond said septa over a maximum distance of approximately 26 cm, preferably of between 16 and 22 cm, measured perpendicularly with respect to the outer surface of the detector, can be used generally, i.e. both for the whole body and for organ-dedicated SPECT imaging.

[0007] The above raised wall should be manufactured from a suitable material, preferably from a high-attenuating material, such as tungsten, lead, gold, tantalum, platinum or iridium. From a cost-performance point of view, tungsten is extremely suitable for this purpose.

[0008] Further the present invention relates to a combination of a gamma detector and a rake collimator, as defined above, wherein the collimator extends outwards in the longitudinal direction of the detector, and to a gamma camera, provided with a combination of a gamma detector and said above-defined collimator.

[0009] In the published Intern. Patent Application no. WO 91/00048 a triangular collimator is described for use in Transmission Image Computed Tomography.
According to the published Intern. Patent application no. WO 99/09431, the sensitivity-resolution couple of the collimator can be improved substantially by using a fan-beam collimator, focusing to a focal line parallel to the patient's body length, which focal line is made to travel through the target organ during the acquisition of the images. This acquisition is performed along one or a plurality of linear orbits (paths) in a direction perpendicular to the patient's body length, and is called the Linear Orbital Acquisition (LOrA) technique. In this arrangement the above sensitivity-resolution couple could be improved with a factor of up to approx. 3. Although the method of SPECT imaging, as described is this patent application, results in substantially improved reconstructed images, the equipment used for reaching this favourable effect is not completely satisfactory. The manufacture of a fan-beam collimator, suitable for the method of SPECT imaging in question, is difficult, hence time-consuming and expensive.

[0010] Therefore the invention also relates to an equipment for performing the above method of SPECT imaging by using the so-called LOrA technique, comprising at least one gamma camera with at least one detector-combined collimator, and a bed for a patient to be examined in such a relative position, that the bed is surrounded by four collimator positions, essentially situated at the angular points of a square (which are only for simplicity reasons chosen to be situated over the bed (a), under the bed (b), and on both sides (c) and (d) of the bed), which positions can be occupied by said at least one collimator. The patient to be examined is fixedly positioned on a bed. According to the present invention, the equipment for performing the above method of imaging by SPECT is characterized in that:

- said detector-combined collimator is a rake collimator as defined hereinbefore, having its at least one raised wall parallel to the bed length;
- the bed is positioned at such a distance from the collimator positions, that in each position the outer edge (extremity) of said collimator's raised wall is approx. 5 cm distanced at most from the patient's body on the bed; and
- the bed is adapted to allow movements vis-à-vis said at least one collimator in two perpendicular directions, both transverse to the bed length, viz. a sideward movement at position (a) or (b) of said at least one collimator and an up and downward movement at position (c) or (d) thereof; or, alternatively, said at least one collimator is adapted to allow movements vis-à-vis the bed in perpendicular directions, all transverse to the bed length, viz. substantially parallel to the bed surface in the positions (a) and (b), and substantially perpendicular to the bed surface in the positions (c) and (d)

[0011] The outer edge (extremity) of said collimator's raised wall should be positioned as close as possible to the patient's body, to improve the sensitivity and resolution of the system. The minimum distance between said extremity and said body depends on the portion of the body (or on the organ) to be examined, but is generally less than approx. 5 cm, preferably, however, approx. 1 cm at most. By positioning the bed at such a distance from the rake collimator positions (this positioning can be adjusted by a computer, preferably by the acquisition computer), in each of these positions the rake collimator's raised wall remains as closest as possible to the patient's body on the bed during the acquisition by the gamma camera along linear orbits. By adapting the bed or the rake collimator in such manner that it allows relative perpendicularly directed movements, as described above, images can be acquired by the gamma camera along four linear orbits performed in mutually transverse directions perpendicular to the patient's body.

[0012] The range of the relative movements of the bed vis-à-vis the collimator or collimators should preferably be at least equal to two times the transverse size of the detector or collimator. The rake collimator(s) forming part of the equipment of the invention has (have) advantageously at least one raised wall, extending beyond the collimator septa over a distance of between approx. 8 and approx. 26 cm. If allround, i.e. not dedicated to the imaging of certain target organs or parts of the body like the head, this length is preferably between 16 and 22 cm (see above).

[0013] It should be emphasized that by the expression "at least one" should be understood: one up to four; more in particular: one, two or four.
So the equipment according to the present invention may conveniently comprise one gamma detector provided with a rake collimator. Such a detector-collimator combination is equipped in such manner that it can be moved from the above-defined position (a) to positions (c), (b) and (d), successively, and vice versa.

[0014] It may be of advantage, however, to include a second gamma detector provided with a rake collimator into the equipment of the present invention. In that case the two detector-collimator combinations are positioned opposite to each other, sandwiching bed plus patient in between, both equipped in such manner that they can be moved from position (a) to position (c), and from position (b) to position (d), respectively, and vice versa.
In case one or two detector-collimator combinations are present in the equipment of the invention, the equipment is preferably so adapted that the bed is movable vis-à-vis the collimator by means of a system of motive members, preferably a combination of a horizontally shifting mobile member at the foot of the bed and a jack for moving the bed into a vertical direction. This system of motive members is explained in more detail in the Examples.

[0015] In an equally advantageous embodiment the equipment of the present invention comprises four gamma detectors with rake collimators, which detector-colli-

mator combinations are so positioned that they occupy positions (a), (b), (c) and (d), respectively, thereby sandwiching bed plus patient in between.
In this embodiment the four detector-collimator combinations are preferably movable vis-à-vis the bed by means of a motive system, preferably a rigid frame of four mutually perpendicular rails, positioned transversally to the bed length, along which the detector-collimator combinations can slide. This motive system is also explained in the Examples.

[0016] It is another merit of the equipment of the present invention that the relative movements of the bed vis-à-vis the detector-collimator combination(s) can be computer controlled (cybernation) by the gamma camera. This advanced system of computer-driven detector-collimator combination(s) relative to the patient's bed enables the user of the system, i.e. the personnel of the clinic or hospital, to examine the patient full-automatically by the improved SPECT imaging technique of the invention.

[0017] By using in the method of imaging by SPECT according to the LOrA technique the above defined equipment of the invention, which is a better accessible equipment as described in the above WO 99/09431, the favourable results obtained therein are maintained, in fact even improved.

[0018] In the above method the usable transverse size dimension of the SPECT device can be fully used, i.e. the target organ size has to be equal at most to the detector transverse size, to acquire a complete set of planar images (i.e. sufficient to reconstruct the activity distribution).
Surprisingly it has been found, that by using in the above tomographic method a collimator with said at least one raised wall, outwards extending from the gamma detector's outer surface, i.e. the surface facing the patient during use, a considerable improvement of the sensitivity-resolution couple can be obtained, even a further improvement with regard to that described in the above WO 99/09431. The construction of such a collimator, provided with at least one raised wall in a transverse position with regard to the collimator septa, is very simple and therefore a cheap substitute for the special fan-beam collimator to be used in WO 99/09431. This simple construction, as used in the present invention, gives even superior results with regard to that described in the above int. patent application. Therefore better reconstructed images can be obtained by using the same acquisition time and the same dose of injected radioactivity. In this manner lesions or other malignancies in the body of a patient can be detected earlier, for example, metastasation of tumours in an early stage of development. At choice, however, the acquisition time can be reduced considerably to obtain, with the same dose of injected radioactivity, images suitable for routine investigations. This results in a reduction of the costs for the clinic or hospital. Also at choice, as a third alternative the dose of injected radioactivity can be reduced in order to burden the patient to a lesser extent. Optionally these advantages can be reached in combination with each other, then, of course, to a somewhat lesser extent but nevertheless with sufficiently attractive prospects.

[0019] Preferably, in the above method the longitudinal length of the gamma detector (= the length of said raised wall) is larger than the thickness of the transverse slices of the patient's body to be imaged and reconstructed.

[0020] It should be emphasized, that by the term "target organ" is not only meant the organ or tissue to be studied or investigated by using the above method, but obviously encompasses a plurality of organs to be studied simultaneously and also a part of the body, like the head, the chest or the abdomen, or even the complete body of the patient.
It is further important to note, that the linear orbits or paths must not necessarily be straight lines, but also encompass slightly curved lines.

Example

[0021] The invention will now be described in greater detail with reference to the accompanying drawings, wherein:

Figures 1 and 2 are schematic representations of the equipment according to the present invention in a suitable embodiment, Fig. 1 viewed in the longitudinal direction of the bed and Fig. 2 viewed in a direction transverse to the bed;
Figure 3 is also a schematic representation of such an equipment of the present invention, now in another suitable embodiment, viewed in the longitudinal direction of the bed, as in Fig. 1;
Figures 4 through 9 show two suitable embodiments of a gamma detector equipped with a rake collimator to be used in the above equipment, figures 4 and 7 in perspective view, figures 5 and 8 viewed from above, and figures 6 and 9 in side-view; and
Figure 10 shows a SPECT spatial revolution image, obtained by performing a model experiment.

Detailed description of the drawings

[0022] Figures 1 and 2 show a gamma detector **1** equipped with a rake collimator **2,** comprising a plurality of collimator septa **24** and a raised wall **23,** as described hereinafter. The detector-collimator combination is movably attached to a circular rail **3** held by two pylons **9.** The detector **1** can move along the rail, the longitudinally positioned raised wall **23** of the collimator **2** always pointing to the rotation axis **8.** Using a magnetic brake, the detector **1** can be positioned over, under, left and right the bed **4:** positions a, b, c and d, respectively (the collimator centres are situated at the angular points of a square). A motor attached to the detector **1** and drawing an endless screw acting on a circular rack attached along the rail **3** can be used to move the detector-collimator

combination from one position into another. The bed **4** can vertically move thanks to the jacks **5,** which can be constituted by a motorized endless screw acting on a rack. A crenelated plate drawing by the endless screw and inserted in an optical switch can be used to adjust the vertical position of the bed **4.** This bed can also move along the left - right direction of Figure 1 (horizontal transverse direction) thanks to the mobile element **7** which can be a trolley rolling along a rail on the floor. Again a motorized endless screw acting on a rack and drawing a crenelated plate inserted in an optical switch can be used to move and adjust the transverse horizontal bed **4** position. The vertical positioning range of the bed **4** vis-à-vis the rotation axis **8** should be optimal with respect to the equipment used, the horizontal positioning range is at least equal to two times the transverse size **6** of the detector **1.** The raised wall **23** is parallel to the bed **4** length and points to the rotation axis **8,** said axis corresponding with a central line through the patient's body on the bed **4.** The distance between the outer edge (extremity) **27** of the raised wall **23** and the body surface is as small as possible, preferably approx. 1 cm at most. The planar images are digitally acquired along four linear orbits: the bed **4** is moved into the various successive vertical positions, when the detector **1** is unmoved left or right the bed **4** (in positions c or d, respectively); the bed is moved into the various successive transverse horizontal positions, when the detector **1** is unmoved over or under the bed **4** (in positions a or b, respectively). During acquisition, the digital planar images and the vertical and horizontal digital bed **4** positions are sent to the treatment computer. The distribution of the radioactivity over the patient's body **A(x,y,z),** wherein **x,y** and **z** are the orthogonal coordinates along the horizontal transverse direction, the vertical direction and the longitudinal direction, respectively, can be computed using the new reconstruction algorithm as disclosed hereinbefore.

A second detector - rake collimator combination may be present in position b of the above equipment, movable along the rail **3** from position b to position d and vice versa, whereas the first combination is then movable from position a to position c and vice versa.

[0023] The embodiment shown in Figure 3 comprises four gamma detectors **11a, 11b, 11c** and **11d,** provided with rake collimators **12a, 12b, 12c** and **12d** (raised walls **not** shown), situated over, under, left and right the bed **14** (positions a, b, c and d, respectively). Each detector can be moved along a rail **(13a, 13b, 13c** and **13d),** perpendicular to the bed **14** length; the rails are attached to each other to constitute a rigid frame.

During the acquisition the detector-collimator combinations move along their rails, the bed being unmoved.

[0024] Figures 4 through 9 show schematically a gamma detector **1** with two different rake collimators **2** and **2a** in more detail. The rake collimator of figures 4-6 is composed of a raised wall **23,** parallel to the longitudinal direction **25** of the detector, and of a plurality of collimator septa **24,** perpendicular to the raised wall and parallel to the transverse direction **26** of the detector. The heigh of the collimator septa is approx. 3 or 4 cm, that of the raised wall approx. 20-25 cm, both measured from the outer surface of the gamma detector.

The rake collimator of figures 7-9 is, in addition to the collimator septa **24,** provided with two raised walls **23a, b,** positioned at both outer edges of the detector and slanted inwards. In cross section (fig. 9) these raised walls form the sides of a trapezium with a topline-length t of between 3 and 12 mm.

The raised walls are manufactured from tungsten. The outer edges of the raised walls **23** and **23a,b** extend from the outer surface of the gamma detector **1** over a distance of approx. 20 to 25 cm, measured perpendicularly with respect to said outer surface. The collimator septa extend from said detector's outer surface over a distance of approx. 3 or 4 cm.

Description of the model experiment

[0025] To acquire real acquisition data, a model experiment has been carried out. In such an experiment the following requirements as to the equipment should be met:

(a) camera plus suitable rake collimator,
(b) suitable radiation source; and
(c) camera plus collimator should be movable vis-à-vis the radiation source or vice versa.

Ad (a). A suitable rake collimator, meeting the requirements of the present invention, namely a collimator corresponding to the figures 4-6 embodiment, has been manufactured. The raised wall, made of tungsten, extends from the outer surface of the gamma detector over a distance of 20 cm. The NaI crystal spatial resolution of the detector is 3 mm.

Ad (b). As the radiation source is used a so-called Jaszczak's de luxe phantom, well-known in the art of performing radioactive experiments.

Ad (c). The radiation source is movable relative to the collimator in such manner that it enables the acquisition of images along linear orbits performed in two directions x and y (horizontal and vertical), perpendicular to the SPECT camera rotation axis z.

[0026] In the above arrangement, the method of the present invention is performed with the radiation source situated at a distance of less than 1 cm from the rake collimator's outer edge (extremity). After a suitable acquisition time, the SPECT spatial resolution of figure 10 is obtained.

From this figure it can be concluded, that the spatial resolution obtained according to the method of the invention is surprisingly good, without any degradation at increasing distance from the collimator.

Claims

1. A collimator for use in the method of imaging a target organ in a patient by SPECT, **characterized in that** the collimator (2, 2^a), a so-called rake collimator, comprises, in addition to a plurality of collimator septa (24) in a mutually parallel arrangement, at least one raised wall (23), considerably larger than the septa and transversally positioned thereto.

2. Collimator as claimed in claim 1, **characterized in that** said rake collimator comprises either a single raised wall (23), perpendicularly extending from a common central line of said septa (24), or two raised walls (23^a, 23^b), slanted inwards from the ends of said septa to form, in cross section, the sides of a trapezium with a topline-length (t) of from approx. 3 to approx. 12 mm.

3. Collimator as claimed in any of claims 1-2, **characterized in that** at least one raised wall extends beyond said septa over a distance of between approx. 8 and approx. 26 cm, preferably of between 16 and 22 cm, measured perpendicularly with respect to the outer surface of the detector.

4. Collimator as claimed in any of claims 1-3, **characterized in that** said at least one raised wall is manufactured from a high-attenuating material, preferably from tungsten, lead, gold, tantalum, platinum or iridium, more preferably from tungsten.

5. A combination of a gamma detector and a collimator, wherein the collimator is defined in any of claims 1-4 and extends outwards in the longitudinal direction of the detector.

6. A gamma camera, provided with a combination of a gamma detector and a collimator, wherein said combination is defined in claim 5.

7. An equipment for performing the method of imaging a target organ in a patient by SPECT, by using the so-called LOrA technique, comprising at least one detector-combined collimator, a bed (4) for a patient to be examined, and means for defining four collimator positions relative to the bed, essentially situated at the angular points of a square, viz. over the bed (a), under the bed (b), and on both sides (c) and (d) of the bed, which positions can be occupied by said at least one collimator;
said equipment being **characterized in that**:

   - said detector-combined collimator ($2,2^a$) is a rake collimator as claimed in any of claims 1-4, having its at least one raised wall ($23,23^{a,b}$) parallel to the bed length;
   - the bed is positioned at such a distance from the collimator positions, that in each position the outer edge (extremity) of said collimator's raised wall is approx. 5 cm distanced at most from the patient's body on the bed; and
   - the bed is adapted (5,7) to allow movements vis-à-vis said detector-combined collimator in two perpendicular directions, both transverse to the bed length, viz. a sideward movement at position (a) or (b) of said at least one collimator, and an up- and downward movement at position (c) or (d) thereof.

8. An equipment for performing the method of imaging a target organ in a patient by SPECT, by using the so-called LOrA technique, comprising at least one detector-combined collimator, a bed (4) for a patient to be examined, and means for defining four collimator positions relative to the bed, essentially situated at the angular points of a square, viz. over the bed (a), under the bed (b), and on both sides (c) and (d) of the bed, which positions can be occupied by said at least one collimator;
said equipment being **characterized in that**:

   - said detector-combined collimator ($2,2^a$) is a rake collimator as claimed in any of claims 1-4, having its at least one raised wall ($23 ,23^{a,b}$) parallel to the bed length;
   - the bed is positioned at such a distance from the collimator positions, that in each position the outer edge (extremity) of said collimator's raised wall is approx. 5 cm distanced at most from the patient's body on the bed; and
   - said at least one detector-combined collimator is adapted (3) to allow movements vis-A-vis the bed in perpendicular directions, all transverse to the bed length, viz. substantially parallel to the bed surface in the positions (a) and (b), and substantially perpendicular to the bed surface in the positions (c) and (d).

9. Equipment as claimed in any of claims 7-8, wherein the equipment comprises one gamma detector provided with a rake collimator as defined in any of claims 1-4, which detector-collimator combination is equipped in such manner that it can be moved from position (a) to positions (c), (b) and (d), successively.

10. Equipment as claimed in any of claims 7-8, wherein the equipment comprises two gamma detectors provided with rake collimators as defined in any of claims 1-4, which detector-collimator combinations are positioned opposite to each other, sandwiching bed plus patient in between, both equipped in such manner that they can be moved from position (a) to position (c), and from position (b) to position (d), respectively.

11. Equipment as claimed in any of claims 7-8, wherein the equipment comprises four gamma detectors with rake collimators as defined in any of claims 1-4, which detector-collimator combinations are so positioned that they occupy positions (a), (b), (c) and (d), respectively, thereby sandwiching bed plus patient in between.

Patentansprüche

1. Kollimator zur Verwendung in dem Verfahren der Bilderzeugung eines Zielorgans in einem Patienten mittels SPECT, **dadurch gekennzeichnet, dass** der Kollimator (2, 2^a), ein so genannter Harken-Kollimator, neben mehreren Kollimatorlamellen (24) in einer gegenseitig parallelen Anordnung mindestens eine erhöhte Wand (23) umfasst, die bedeutend größer als die Lamellen und quer zu diesen angeordnet ist.

2. Kollimator nach Anspruch 1, **dadurch gekennzeichnet, dass** der Harken-Kollimator entweder eine einzige erhöhte Wand (23) umfasst, die sich senkrecht von einer gemeinsamen Mittellinie der Lamellen (24) erstreckt, oder zwei erhöhte Wände (23^a, 23^b), die von den Enden der Lamellen so nach innen geneigt sind, dass sie im Querschnitt die Seiten eines Trapezes mit einer Oberseitenlänge (t) von etwa 3 mm bis etwa 12 mm bilden.

3. Kollimator nach einem der Ansprüche 1 und 2, **dadurch gekennzeichnet, dass** sich mindestens eine erhöhte Wand über die Lamellen hinaus über eine Strecke von etwa 8 bis etwa 26 cm, bevorzugt von 16 bis 22 cm, erstreckt, senkrecht in Bezug auf die Außenfläche des Detektors gemessen.

4. Kollimator nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** die mindestens eine erhöhte Wand aus einem hoch-dämpfenden Material, bevorzugt aus Wolfram, Blei, Gold, Tantal, Platin oder Iridium, bevorzugter aus Wolfram, hergestellt ist.

5. Kombination aus einem Gamma-Detektor und einem Kollimator, wobei der Kollimator nach einem der Ansprüche 1 bis 4 definiert ist und sich nach außen in Längsrichtung des Detektors erstreckt.

6. Gamma-Kamera, die mit einer Kombination aus einem Gamma-Detektor und einem Kollimator versehen ist, wobei die Kombination nach Anspruch 5 definiert ist.

7. Vorrichtung zum Durchführen des Verfahrens der Bilderzeugung eines Zielorgans in einem Patienten mittels SPECT, unter Verwendung der so genannten LOrA-Technik, die mindestens einen mit einem Detektor kombinierten Kollimator, ein Bett (4) für den zu untersuchenden Patienten und Mittel zum Festlegen von vier Kollimatorpositionen bezogen auf das Bett umfasst, welche sich im Wesentlichen an den Winkelpunkten eines Quadrates, d.h. über dem Bett (a), unter dem Bett (b) und auf beiden Seiten (c) und (d) des Betts befinden, wobei die Positionen von dem mindestens einen Kollimator besetzt werden können,
wobei die Vorrichtung **dadurch gekennzeichnet ist, dass**:

- der mit einem Detektor kombinierte Kollimator (2, 2^a) ein Harken-Kollimator nach einem der Ansprüche 1 bis 4 ist, dessen mindestens eine erhöhte Wand (23, $23^{a,b}$) sich parallel zur Bettlänge befindet,
- das Bett in einem solchen Abstand von den Kollimatorpositionen angeordnet ist, dass in jeder Position die Außenkante (Extremität) der erhöhten Wand des Kollimators höchstens etwa 5 cm von dem Körper des Patienten auf dem Bett beabstandet ist, und
- das Bett so eingerichtet ist (5, 7), dass es Bewegungen gegenüber dem mit einem Detektor kombinierten Kollimator in zwei senkrechte Richtungen ermöglicht, sowohl quer zur Bettlänge, d.h. eine Seitwärtsbewegung an Position (a) oder (b) des mindestens einen Kollimators und eine Auf- und Abwärtsbewegung an seiner Position (c) oder (d).

8. Vorrichtung zum Durchführen des Verfahrens der Bilderzeugung eines Zielorgans in einem Patienten mittels SPECT, unter Verwendung der so genannten LOrA-Technik, die mindestens einen mit einem Detektor kombinierten Kollimator, ein Bett (4) für den zu untersuchenden Patienten und Mittel zum Festlegen von vier Kollimatorpositionen bezogen auf das Bett umfasst, welche sich im Wesentlichen an den Winkelpunkten eines Quadrates, d.h. über dem Bett (a), unter dem Bett (b) und auf beiden Seiten (c) und (d) des Betts befinden, wobei die Positionen von dem mindestens einen Kollimator besetzt werden können,
wobei die Vorrichtung **dadurch gekennzeichnet ist, dass**:

- der mit einem Detektor kombinierte Kollimator (2, 2^a) ein Harken-Kollimator nach einem der Ansprüche 1 bis 4 ist, dessen mindestens eine erhöhte Wand (23, $23^{a,b}$) sich parallel zur Bettlänge befindet,
- das Bett in einem solchen Abstand von den Kollimatorpositionen angeordnet ist, dass in jeder Position die Außenkante (Extremität) der erhöhten Wand des Kollimators höchstens etwa

5 cm von dem Körper des Patienten auf dem Bett beabstandet ist, und
- der mindestens eine mit einem Detektor kombinierte Kollimator so eingerichtet ist (3), dass er Bewegungen gegenüber dem Bett in senkrechten Richtungen ermöglicht, die alle quer zur Bettlänge liegen, d.h. parallel zur Bettoberfläche in den Positionen (a) und (b) und im Wesentlichen senkrecht zur Bettoberfläche in den Positionen (c) und (d).

9. Vorrichtung nach einem der Ansprüche 7 bis 8, wobei die Vorrichtung einen Gamma-Detektor umfasst, der mit einem Harken-Kollimator nach einem der Ansprüche 1 bis 4 versehen ist, wobei die Detektor-Kollimator-Kombination solcherart ausgestattet ist, dass sie aus der Position (a) sukzessive in die Positionen (c), (b) und (d) bewegt werden kann.

10. Vorrichtung nach einem der Ansprüche 7 bis 8, wobei die Vorrichtung zwei Gamma-Detektoren umfasst, die mit Harken-Kollimatoren nach einem der Ansprüche 1 bis 4 versehen sind, wobei die Detektor-Kollimator-Kombinationen einander gegenüber angeordnet sind und dabei das Bett plus Patient zwischen sich bringen, wobei beide solcherart ausgestattet ist, dass sie aus der Position (a) in die Positionen (c), bzw. aus der Position (b) in die Position (d) bewegt werden können.

11. Vorrichtung nach einem der Ansprüche 7 bis 8, wobei die Vorrichtung vier Gamma-Detektoren mit Harken-Kollimatoren nach einem der Ansprüche 1 bis 4 umfasst, wobei die Detektor-Kollimator-Kombinationen so angeordnet sind, dass sie die Positionen (a), (b), (c) bzw. (d) einnehmen und dabei das Bett plus Patient zwischen sich bringen.

Revendications

1. Collimateur pour une utilisation dans le procédé d'imagerie d'un organe cible dans un patient par SPECT, **caractérisé en ce que** le collimateur (2, 2^a), ce que l'on appelle un collimateur à râteau, comprend, en plus d'une pluralité de septa de collimateur (24) dans un agencement réciproquement parallèle, au moins une paroi surélevée (23), considérablement plus grande que les septa et positionnée transversalement par rapport à ceux-ci.

2. Collimateur selon la revendication 1, **caractérisé en ce que** ledit collimateur à râteau comprend soit une seule paroi surélevée (23), s'étendant perpendiculairement à partir d'une ligne centrale commune desdits septa (24), soit deux parois surélevées (23^a, 23^b), inclinées vers l'intérieur à partir des extrémités desdits septa pour former, en coupe transversale, les côtés d'un trapèze avec une longueur de ligne supérieure (t) d'environ 3 mm à environ 12 mm.

3. Collimateur selon l'une quelconque des revendications 1 et 2, **caractérisé en ce qu'**au moins une paroi surélevée s'étend au-delà desdits septa sur une distance d'environ 8 cm à environ 26 cm, de préférence entre 16 cm et 22 cm, mesurée perpendiculairement à la surface extérieure du détecteur.

4. Collimateur selon l'une quelconque des revendications 1 à 3, **caractérisé en ce qu'**au moins une paroi surélevée est fabriquée dans un matériau à forte atténuation, de préférence du tungstène, du plomb, de l'or, du tantale, du platine ou de l'iridium, et encore plus de préférence du tungstène.

5. Combinaison d'un détecteur gamma et d'un collimateur, dans lequel le collimateur est défini selon l'une quelconque des revendications 1 à 4 et s'étend vers l'extérieur dans la direction longitudinale du détecteur.

6. Caméra gamma, dotée d'une combinaison d'un détecteur gamma et d'un collimateur, dans laquelle ladite combinaison est définie selon la revendication 5.

7. Equipement pour exécuter le procédé d'imagerie d'un organe cible dans un patient par SPECT, en utilisant la technique appelée LOrA, comprenant au moins un collimateur combiné à un détecteur, un lit (4) pour un patient à examiner, et des moyens pour définir quatre positions de collimateur par rapport au lit, essentiellement situées à des points angulaires d'un carré, c'est-à-dire sur le lit (a), sous le lit (b), et des deux côtés (c) et (d) du lit, lesdites positions pouvant être occupées par ledit au moins un collimateur ;
ledit équipement étant **caractérisé en ce que** :

- ledit collimateur combiné à un détecteur (2, 2^a) est un collimateur à râteau selon l'une quelconque des revendications 1 à 4, ayant sa au moins une paroi surélevée (23, $23^{a,b}$) parallèle à la longueur du lit ;
- le lit est positionné à une distance des positions de collimateur de manière à ce que dans chaque position, le bord extérieur (extrémité) de la paroi surélevée dudit collimateur est à une distance d'environ 5 cm au plus du corps du patient sur le lit ; et
- le lit est adapté (5, 7) pour permettre des mouvements par rapport au dit collimateur combiné à un détecteur dans deux directions perpendiculaires, toutes les deux transversales par rapport à la longueur du lit, c'est-à-dire un mouvement vers le côté à la position (a) ou (b) dudit au moins un collimateur, et un mouvement vers

le haut et vers le bas à la position (c) ou (d) de celui-ci.

8. Equipement pour exécuter le procédé d'imagerie d'un organe cible dans un patient par SPECT, en utilisant la technique appelée LOrA, comprenant au moins un collimateur combiné à un détecteur, un lit (4) pour un patient à examiner, et des moyens pour définir quatre positions de collimateur par rapport au lit, essentiellement situées à des points angulaires d'un carré, c'est-à-dire sur le lit (a), sous le lit (b), et des deux côtés (c) et (d) du lit, lesdites positions pouvant être occupées par ledit au moins un collimateur ;
ledit équipement étant **caractérisé en ce que** :

- ledit collimateur combiné à un détecteur (2, 2^a) est un collimateur à râteau selon l'une quelconque des revendications 1 à 4, ayant sa au moins une paroi surélevée (23, $23^{a,b}$) parallèle à la longueur du lit ;
- le lit est positionné à une distance des positions de collimateur de manière à ce que dans chaque position, le bord extérieur (extrémité) de la paroi surélevée dudit collimateur est à une distance d'environ 5 cm au plus du corps du patient sur le lit ; et
- ledit au moins un collimateur combiné à un détecteur est adapté (3) pour permettre des mouvements par rapport au lit dans des directions perpendiculaires, toutes transversales par rapport à la longueur du lit, c'est-à-dire sensiblement parallèles à la surface du lit dans les positions (a) et (b), et sensiblement perpendiculaires à la surface du lit dans les positions (c) et (d).

9. Equipement selon l'une quelconque des revendications 7 et 8, dans lequel l'équipement comprend un détecteur gamma fourni avec un collimateur à râteau défini selon l'une quelconque des revendications 1 à 4, ladite combinaison de détecteur et collimateur étant équipée de manière à pouvoir se déplacer de la position (a) aux positions (c), (b) et (d) successivement.

10. Equipement selon l'une quelconque des revendications 7 et 8, dans lequel l'équipement comprend deux détecteurs gammas fournis avec des collimateurs à râteau comme cela est défini selon l'une quelconque des revendications 1 à 4, lesdites combinaisons de détecteurs et de collimateurs étant positionnées à l'opposé l'une de l'autre, en prenant en sandwich le lit et le patient entre elles, toutes les deux étant équipées de manière à pouvoir se déplacer de la position (a) à la position (c) et de la position (b) à la position (d) respectivement.

11. Equipement selon l'une quelconque des revendications 7 et 8, dans lequel l'équipement comprend quatre détecteurs gammas avec des collimateurs à râteau comme cela est défini selon l'une quelconque des revendications 1 à 4, lesdites combinaisons de détecteurs et de collimateurs étant positionnées de manière à occuper les positions (a), (b), (c) et (d) respectivement, pour ainsi prendre en sandwich le lit et le patient entre elles.

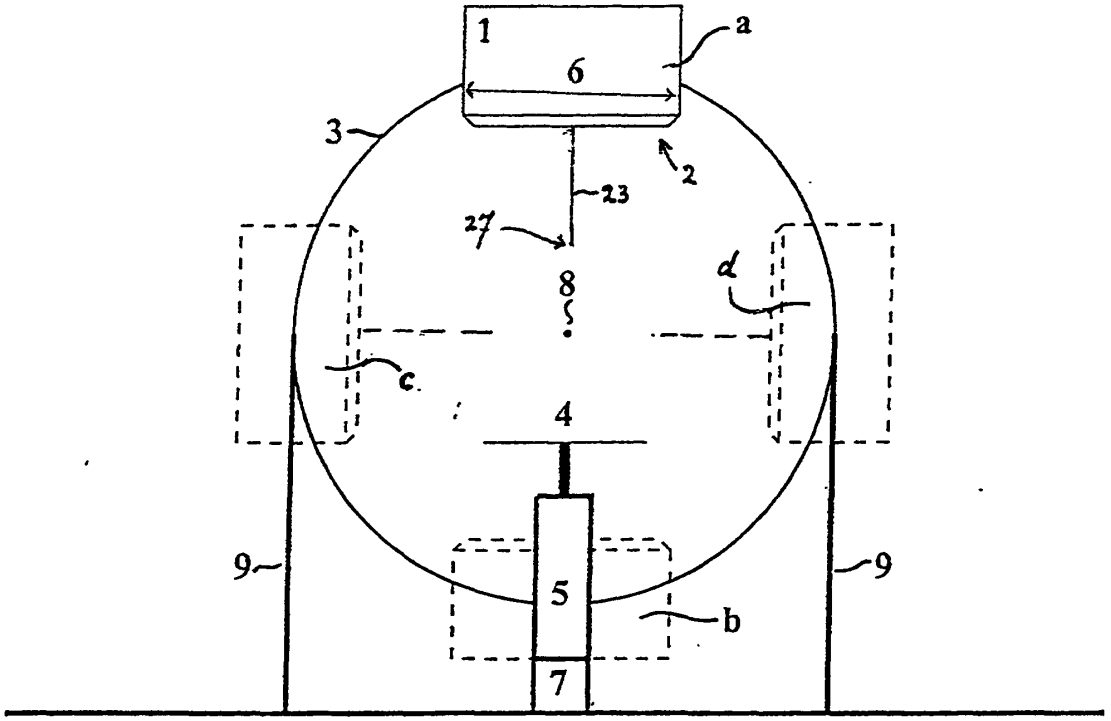
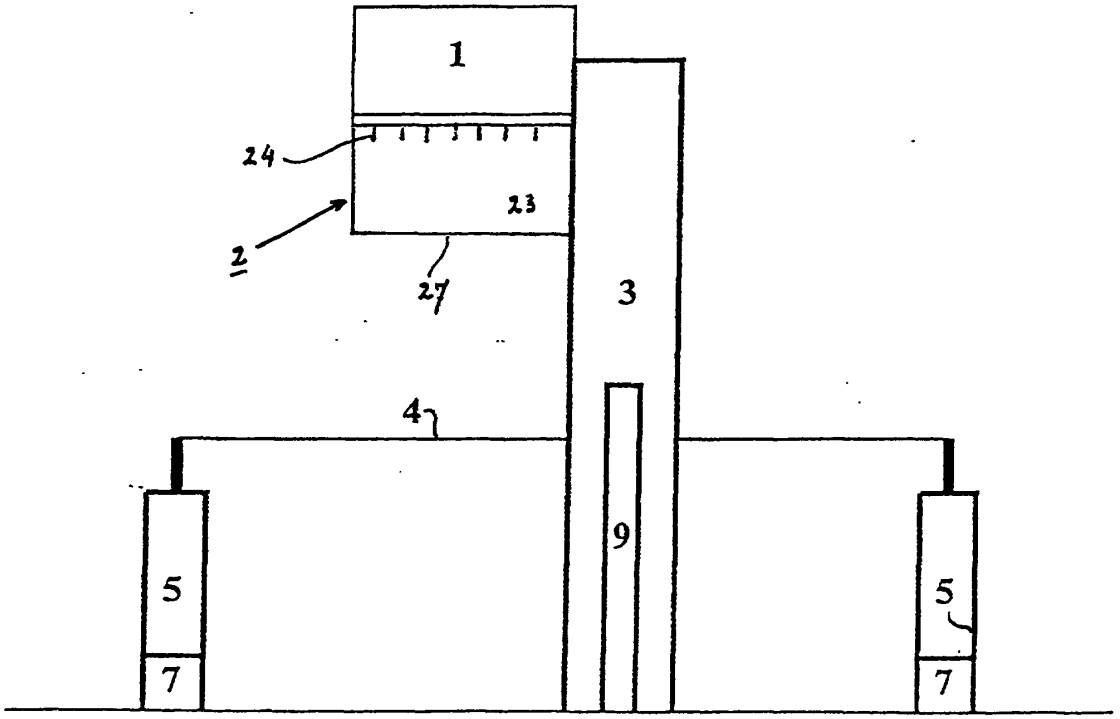


fig.1



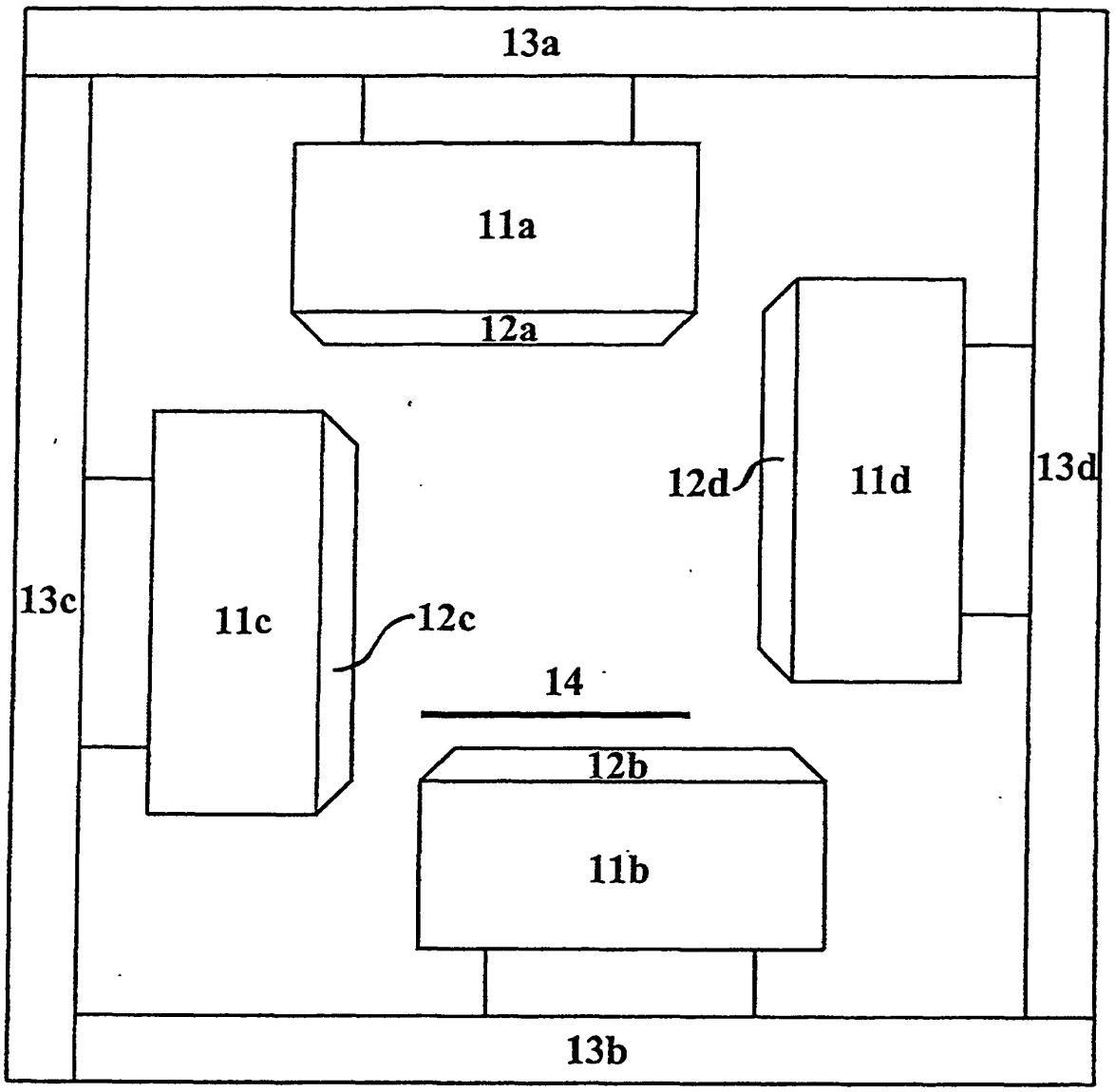


fig. 3

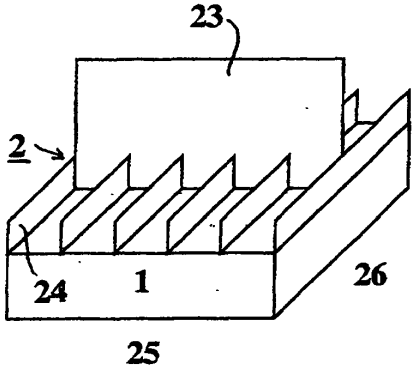
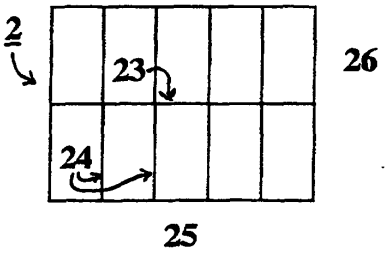


fig 4



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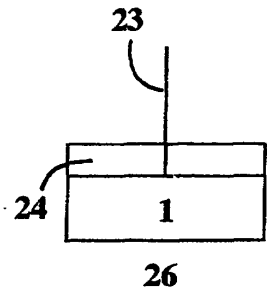

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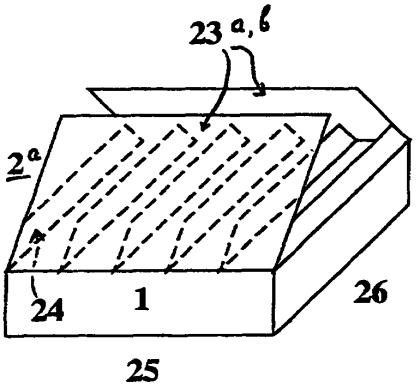
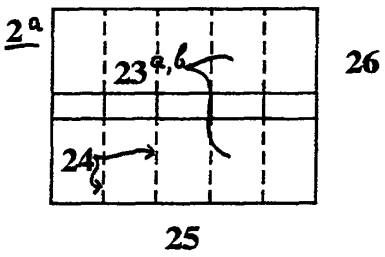


fig 7



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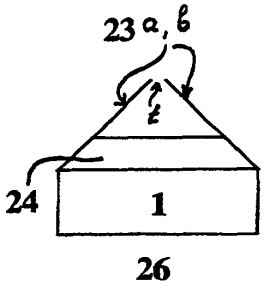

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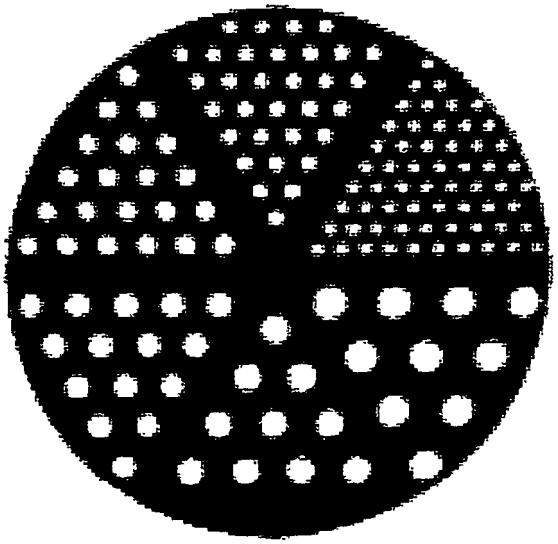

fig. 10

REFERENCES CITED IN THE DESCRIPTION

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